15662 RC

Human-in-the-loop Simulation-based Combat Vehicle Duty Cycle Measurement: Duty Cycle Experiment 1 (06S-SIW-080)

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Outline

- Duty Cycle Experiments
- Simulation Objectives
- Simulation Design
- Experiment Design
- Results
- Conclusions

Duty Cycle Experiments

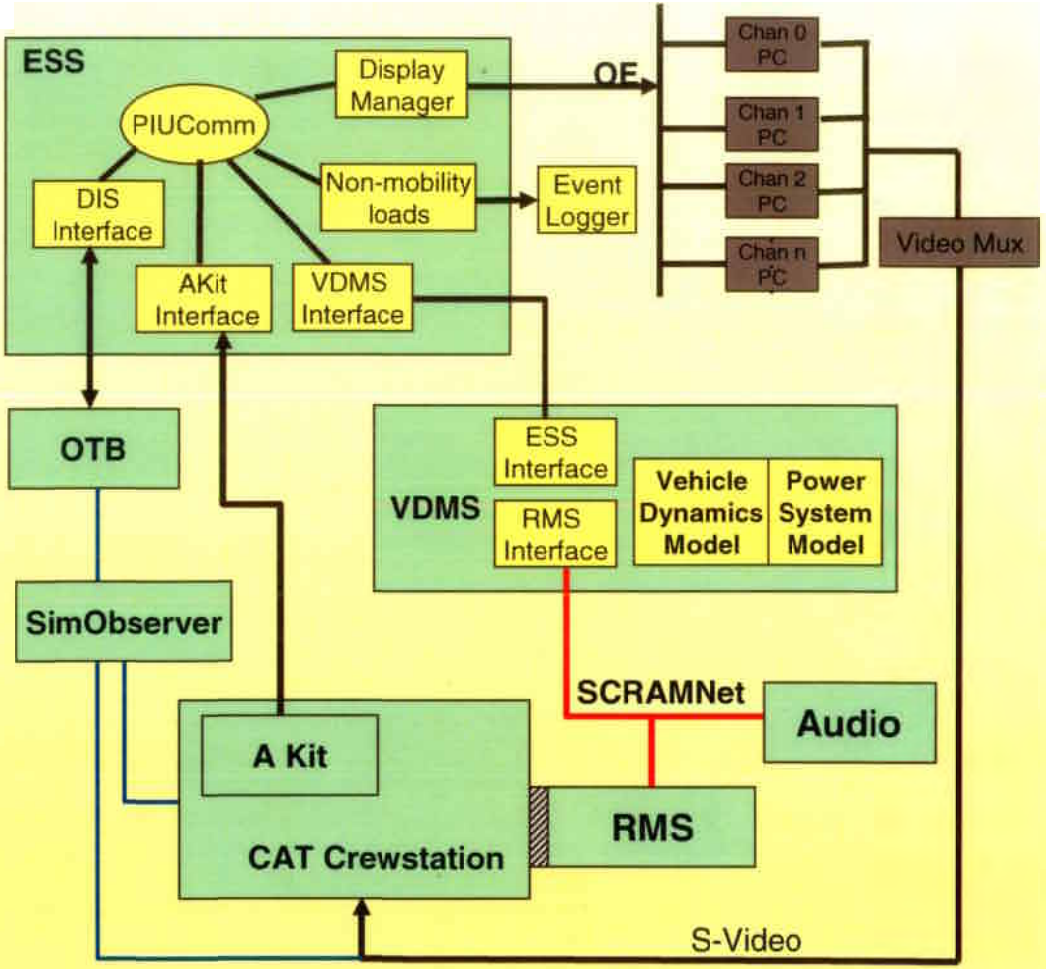
- TARDEC has a Power & Energy program to develop future vehicle power systems.
- Design requires understanding of use.
- To measure use, vehicle must exist.
- Duty cycle experiments use simulation to measure duty cycles of notional vehicles.
- Duty cycle captures:
  - Operator (driver/gunner) use
  - External events

Simulation Objectives

- Create motion based simulation to invoke realistic driving behaviors
- Measure power usage of modeled vehicle during simulated battle
  - Mobility Loads
  - Non-Mobility Loads
- Move towards hardware-in-the-loop experiment

Simulation Design: Top Level

- 6 Major Components
- 12 Computers
- Communications
  - Ethernet
  - SCRAMNet
- Performance:
  - Model update: 500 Hz
  - System Latency: 247 ms



Simulation Design: RMS

Platform Payload	1,600 lbs.
Platform Diameter	46 inches
Acceleration Bandwidth	40 Hz
Axes Displacement	
Linear (vert., lat., long.)	± 20 in.
Angular (roll, pitch, yaw)	± 20 °
Axes Velocity	
Linear (vert., lat., long.)	± 50 in./s
Angular (roll, pitch, yaw)	± 70 °/s
Axes Acceleration	
Linear (vert., lat., long.)	± 2 g's
Angular (roll, pitch, yaw)	± 1150 °/s2

Applications

Man-in-the-loop simulation
- Human/Robotic Investigations
- Crew station design
- HLA exercises/war-gaming

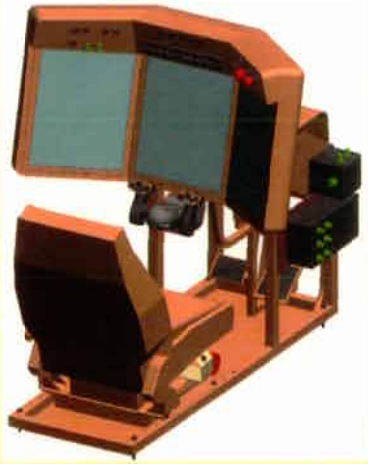
Crew station and component development
- Seat characterization
- Hardware component testing

Motion Drive
- Washout Algorithms
- Real-time Vehicle Dynamics
- Control Loaders
- Function Generator
- Random Signal Generator

Data Acquisition
- Soldier Performance
- Vehicle Performance
- HLA Battlefield Scenarios
- Simulator Performance

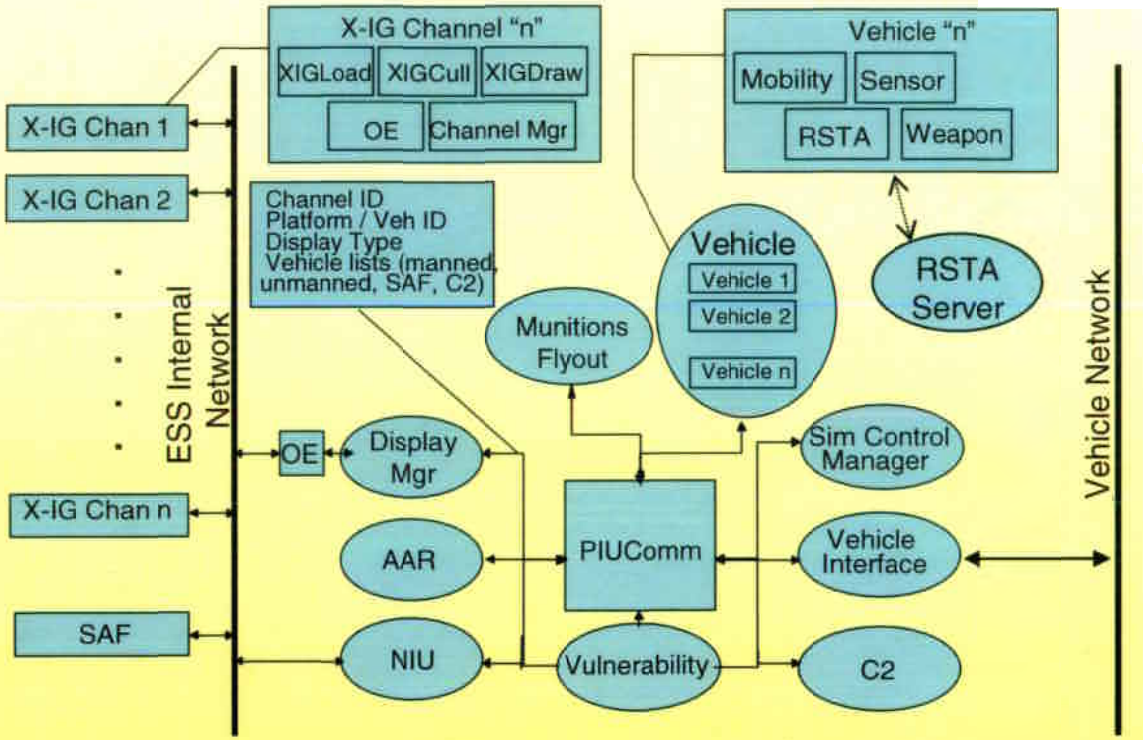
Simulation Design: CAT Crewstation

- Research tool for future crewstations
- 3 touch screens
  - 6 virtual displays
- Multi-function
- Soft button + hard button
- Yoke + Pedals
- "Drive" function



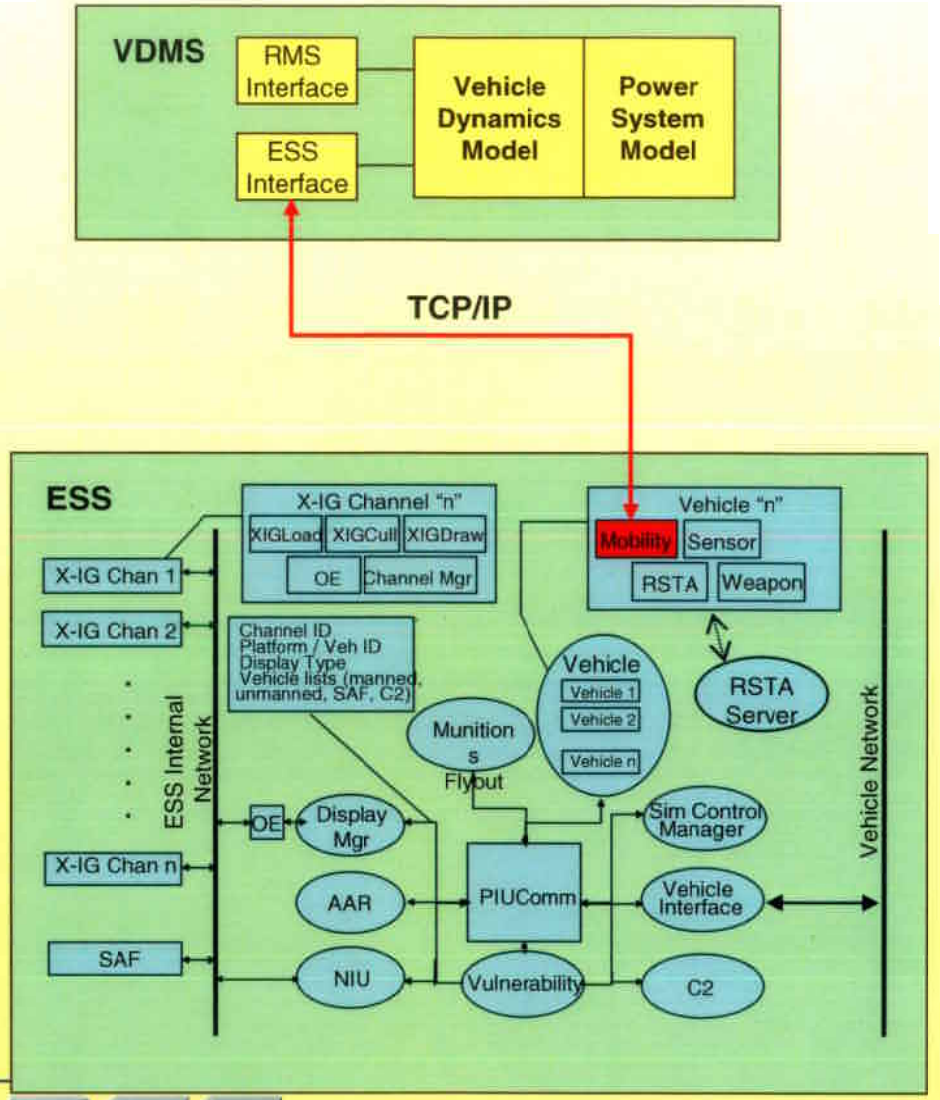
Simulation Design: ESS

- Provided with CAT
  - Training
  - Mission Rehearsal
- Used as DCE IG
- Based on open architecture
- Interfaces to OTB
- "Mobility" process replaced with VDMS



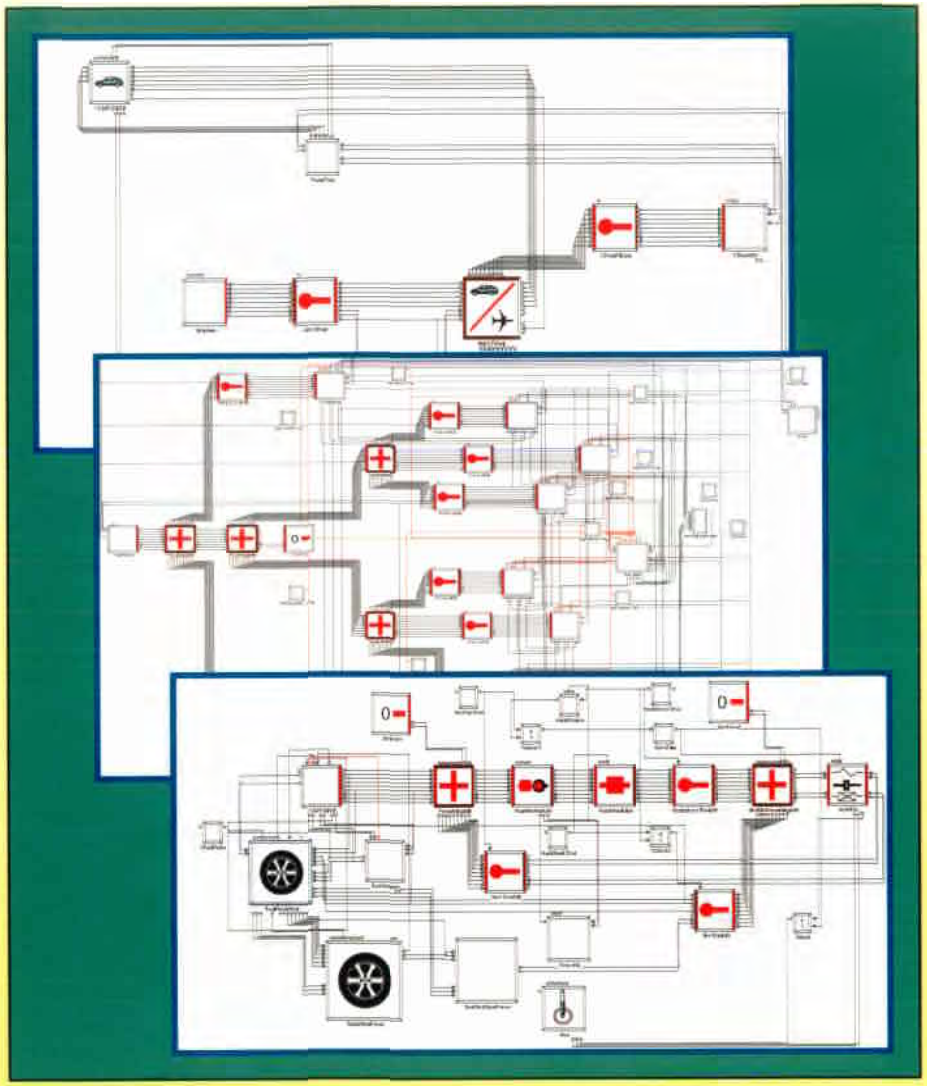
Simulation Design: VDMS

- VDMS is a process:
  - Real-time Dynamics
  - Power Train
  - Terrain Model
  - Interfaces to external systems.
- Deliver dynamic models in executable form.
- Can be used to simulate unmanned or manned vehicles.



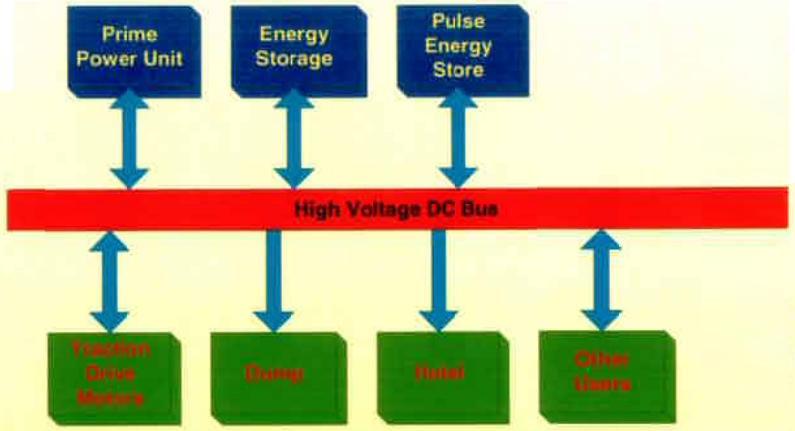
Simulation Design: Vehicle Dynamics

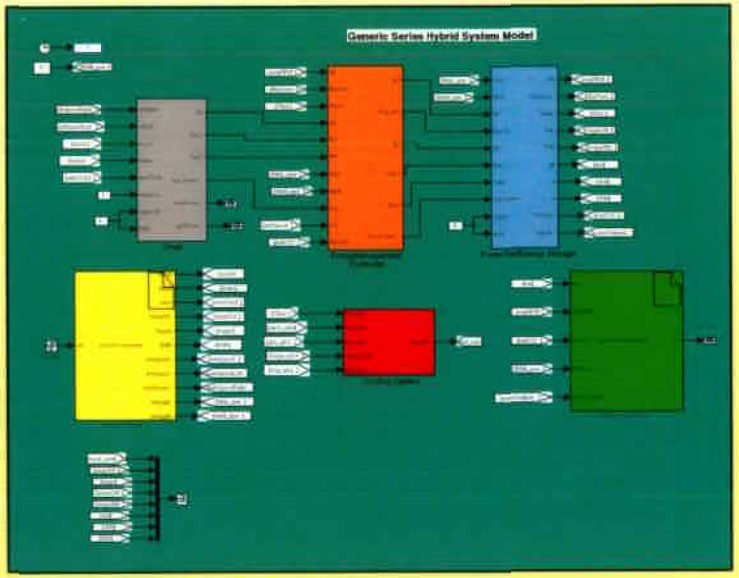
- 24T Tracked Vehicle (MCS)
- Front-drive
- 6 road wheels/side
- SimCreator®'s Multi-body Dynamics
- Executes in VDMS
- Interfaces to Power System



Simulation Design: Power System

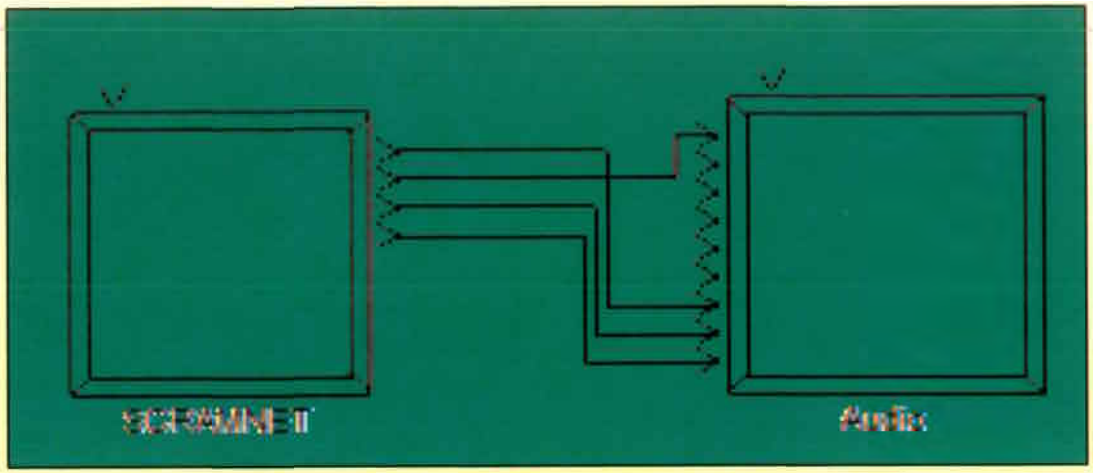
- Series Hybrid Power System for MCS
- Independent Left/Right
- Diesel Engine/Generator
- 600 V bus w/Battery
- Two 300kW traction motors.
- Includes thermal model
- Implemented in Simulink w/ Real-time workshop





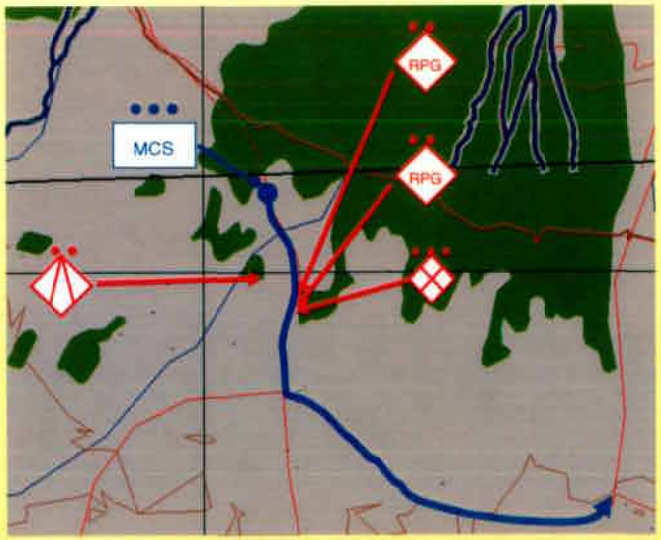
Simulation Design: Audio System

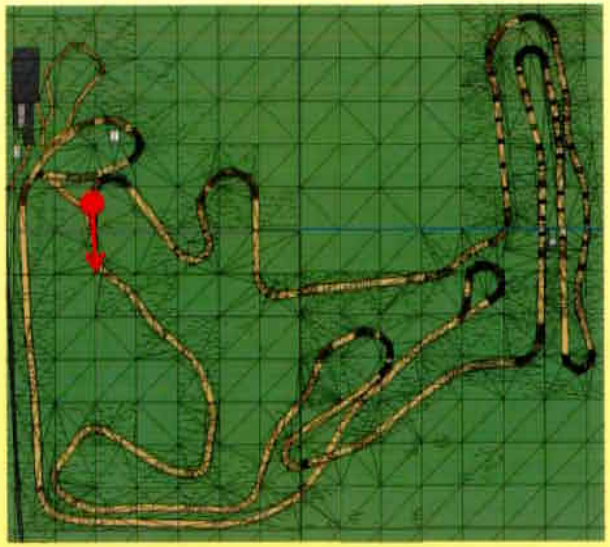
- Internal sounds
  - Engine
  - Track
  - Engine RPM & vehicle speed change sound
- External sounds
  - Battle noise
  - Bullet Pings



Experiment Design: Two Experiments

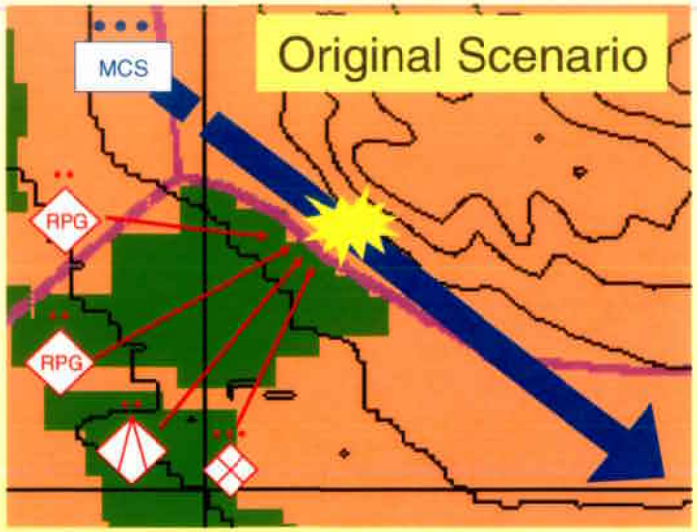
- DCE1
  - Formal Study
  - Battle scenario
  - 9 civilian subjects
- DCE1.1
  - Informal follow-on
  - Driving scenario
  - 7 civilian subjects

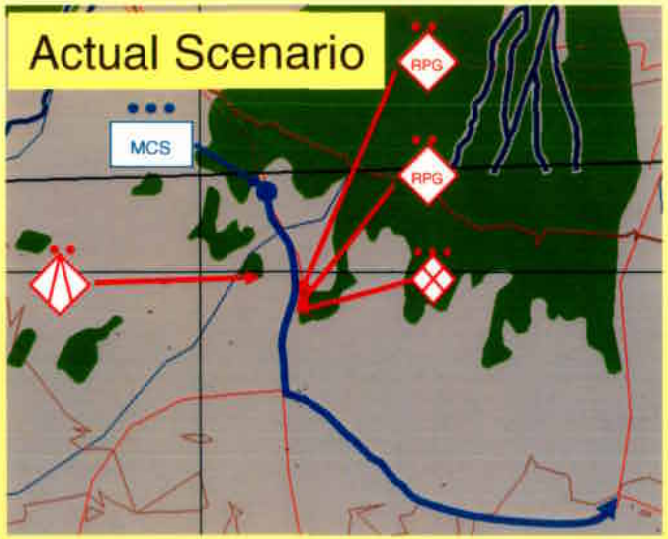




DCE1: Experiment Design

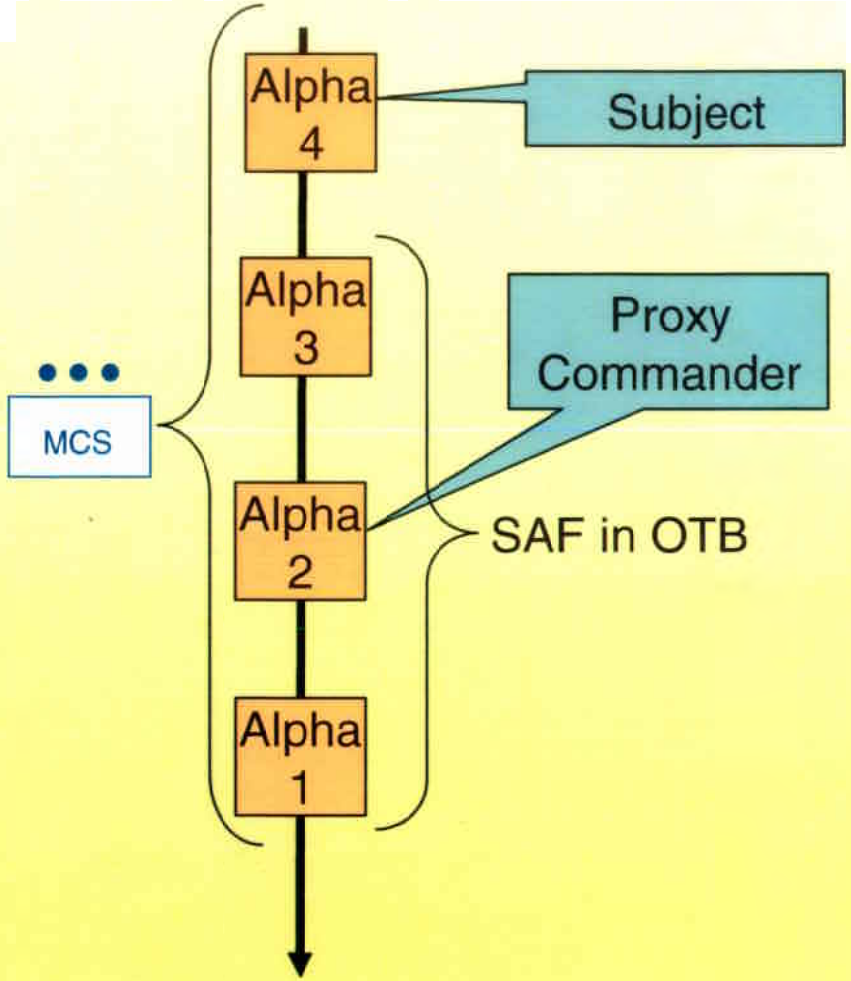
- Assess aggregate power consumption using CASTFOREM
- Extract vignette
  - 9 hours into battle
  - MCS PLT
  - Road March (12 km)
  - Dismount ambush
- Drive + defensive systems





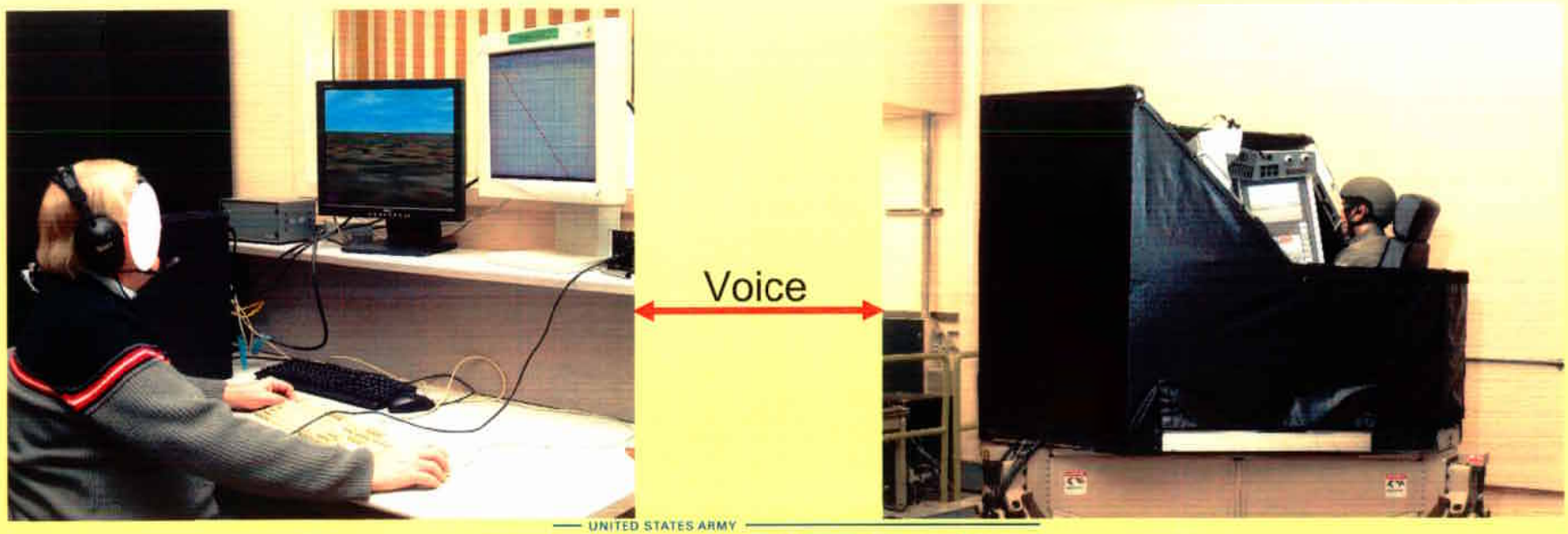
DCE1: OTB Implementation

- Implemented in OTB 2.0
- Blue forces:
  - 3 SAF M1
    - "Alpha 1" – "Alpha 3"
  - 1 Virtual MCS
    - "Alpha 4"
- Red forces
  - RPG
  - ATGM



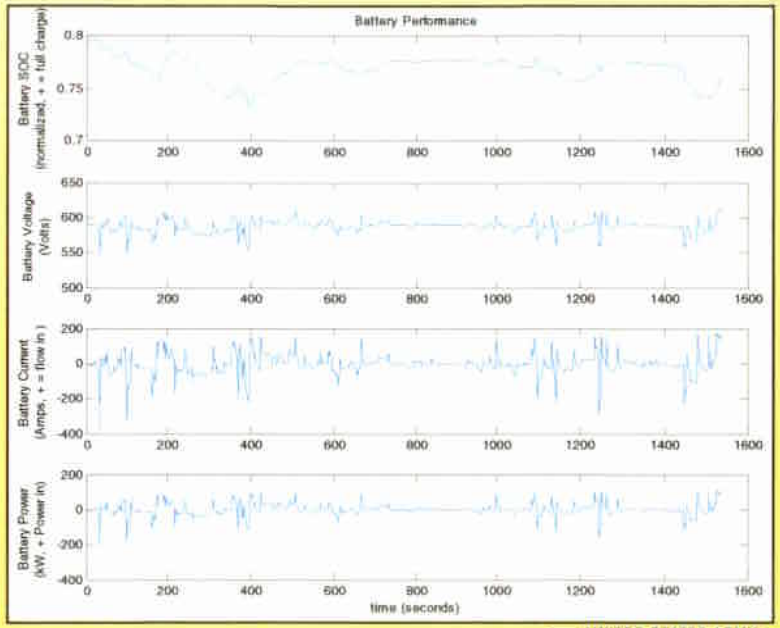
DCE1: Proxy Commander

- Serve as PLT leader
- Give direction
- Maintain "chatter"
- Give mission briefing
- Monitors OTB



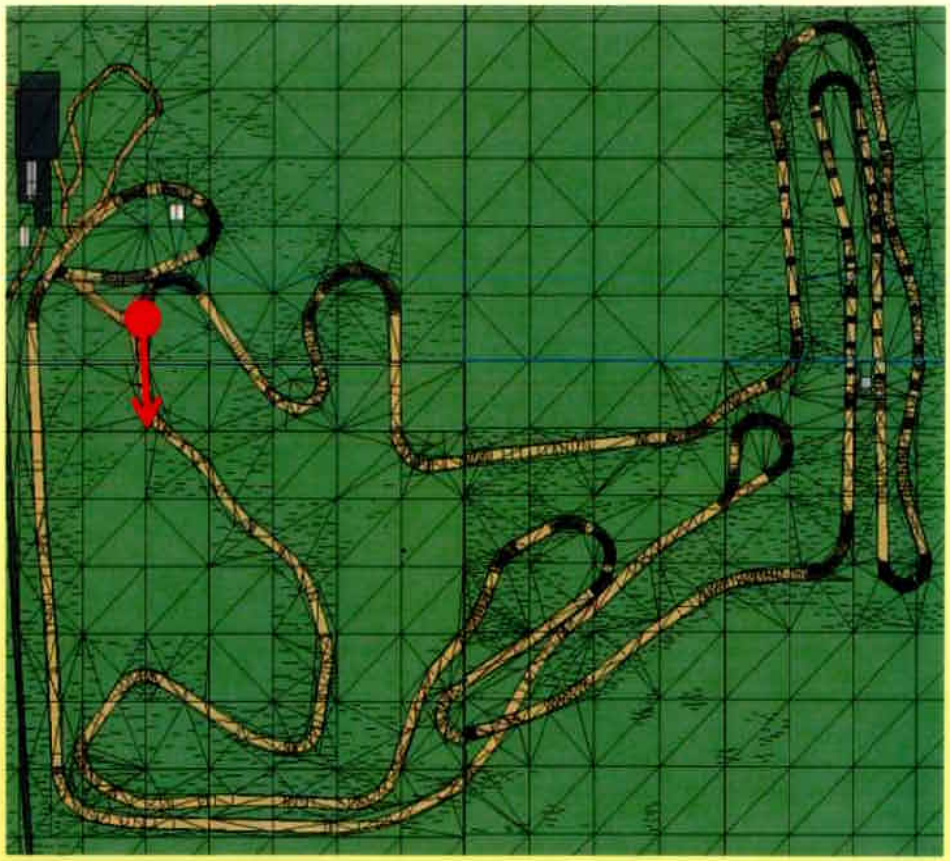
DCE1: Data Acquisition

- 57 channels of data at 100 Hz
  - 31 vehicle dynamics
  - 26 power system
- Video of experiment
- Events
  - hit,
  - transmission
- PDU log



DCE1.1: Experiment Design

- Drive one lap on hilly Army proving ground course.
- Record driver commands, speed, location.
- Seven subjects drawn from experimenters



DCE1: Subject Handling

- Affidavits and questionnaires
  - Consent form
  - Simulation Sickness Questionnaire (1 of 3)
  - Demographics Questionnaire
- Mission Briefing
- Practice drive
- Simulation Sickness Questionnaire (2 of 3)
- Conduct experiment
- Simulation Sickness Questionnaire (3 of 3)
- Exit Interview

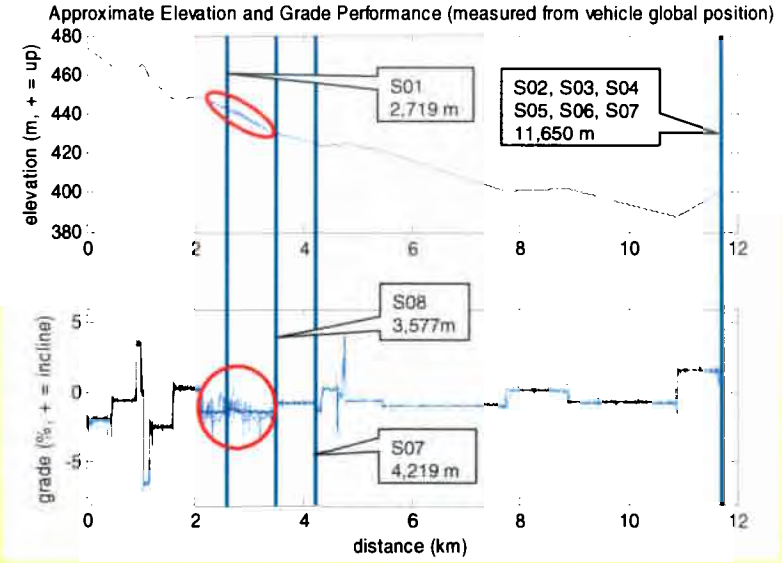
~ 2 hours

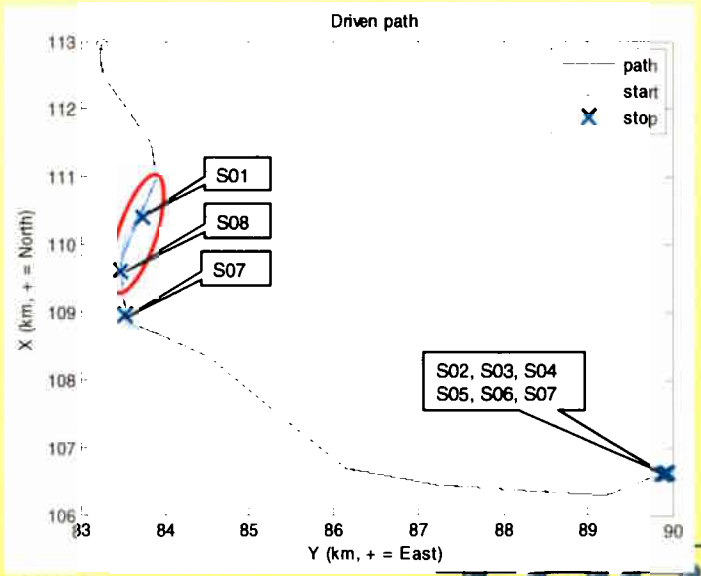
DCE1 Results: Demographics

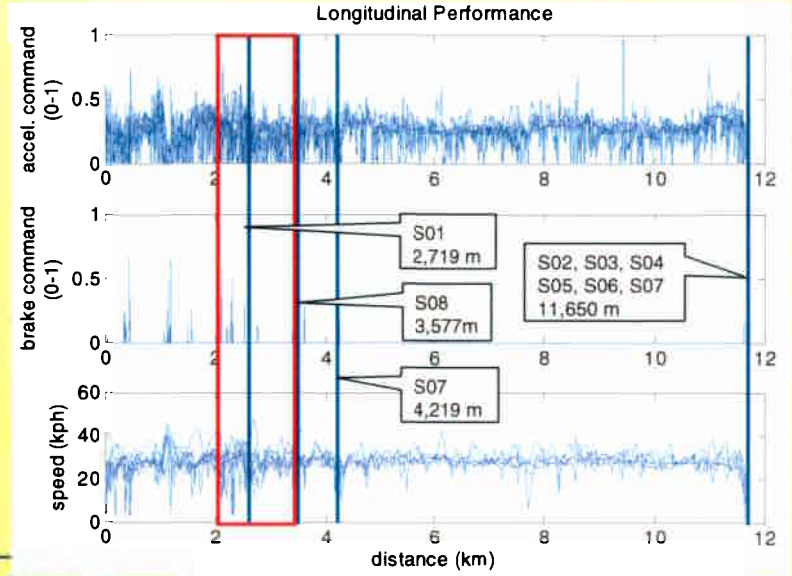
- 9 Subjects (7 male, 2 female)
  - Age 29 ± 2.2 years
  - Education: 4.7 years ± 0.3 yrs post HS.
  - Driving exp: 13 ± 2.4 yrs.
  - Military vehicle exp: 5 subjects
    - None with tracked vehicle exp
  - Computer use: 46 ± 7 hrs/wk.
  - Video game exp: 5.8 ± 1.5 hrs/mo.

DCE1 Results: Duty cycle

- 6 subjects completed
- 3 ended early – computer crash
- No significant simulator sickness







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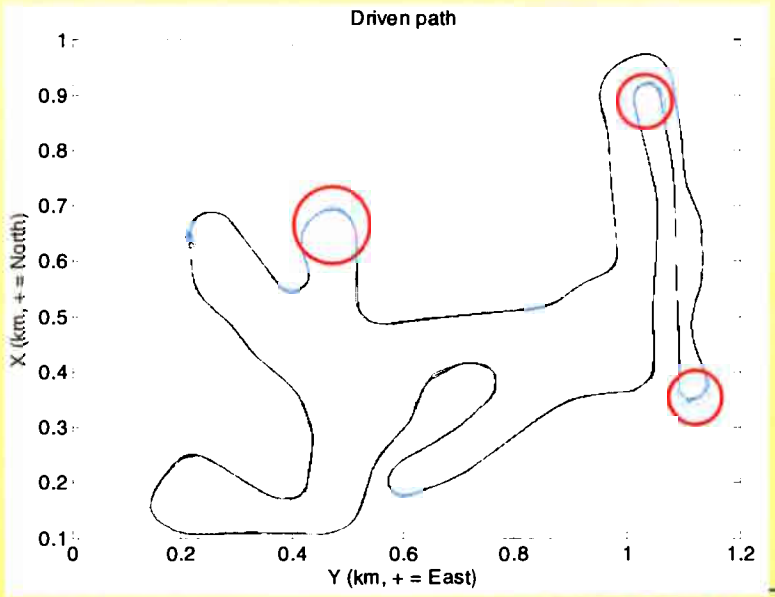
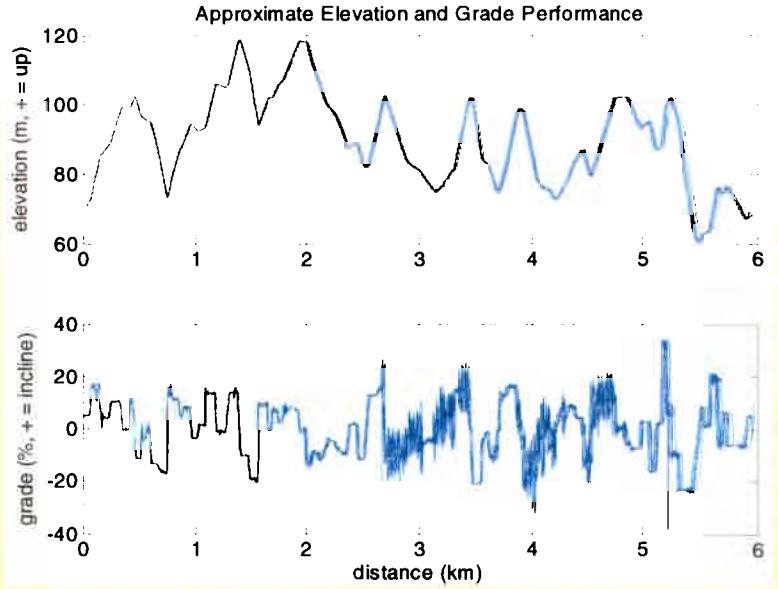
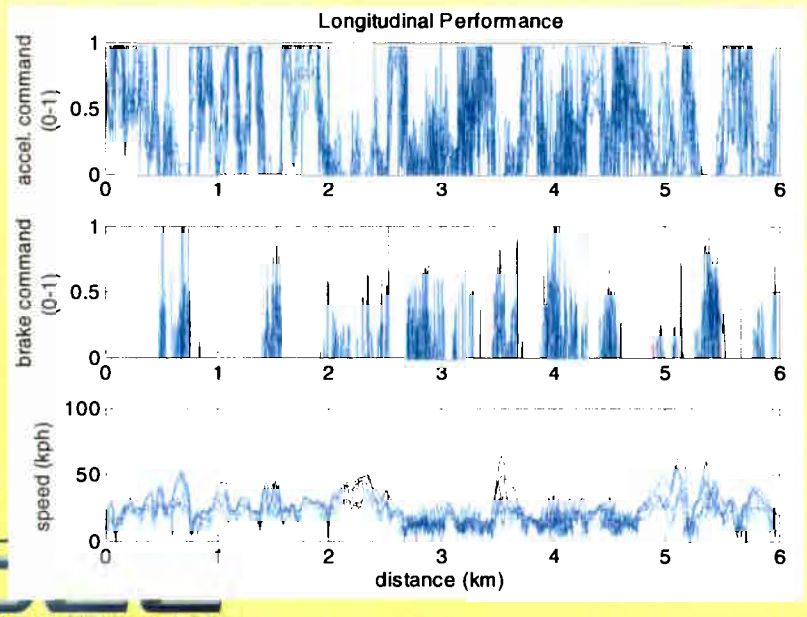
DCE1.1 Results: Duty cycle

- 7 subjects completed
- Lap times
  - –14.2 – 22.4 minutes
- Turns divergence

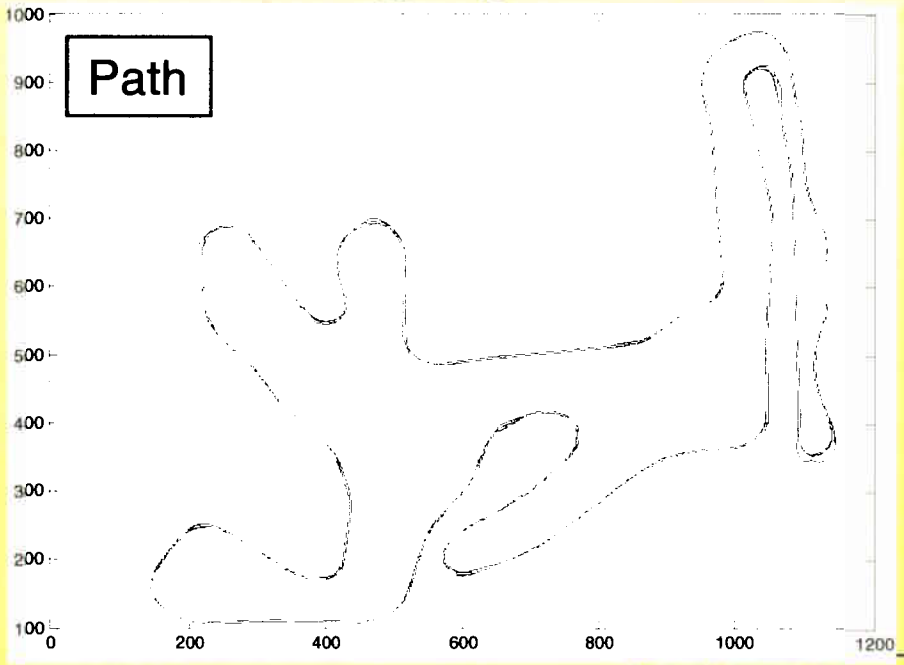


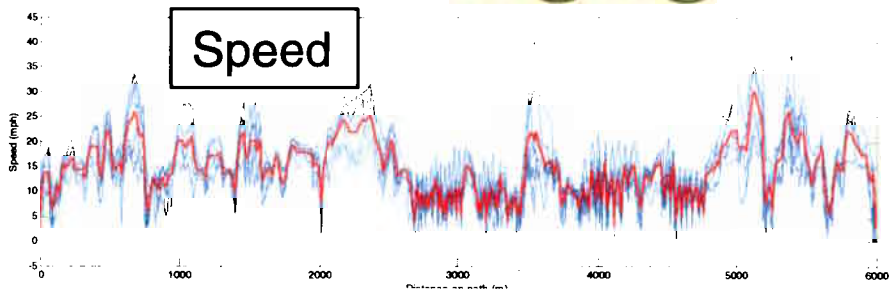


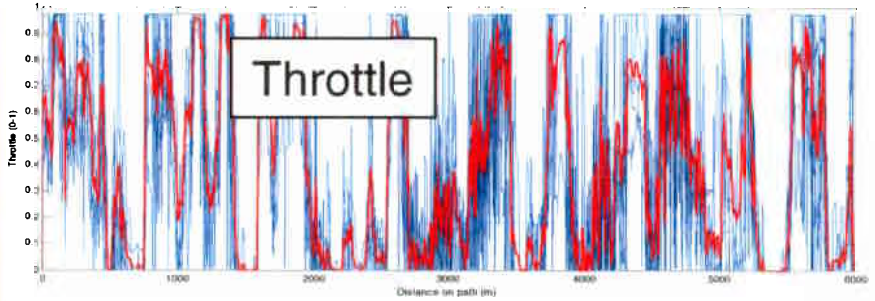


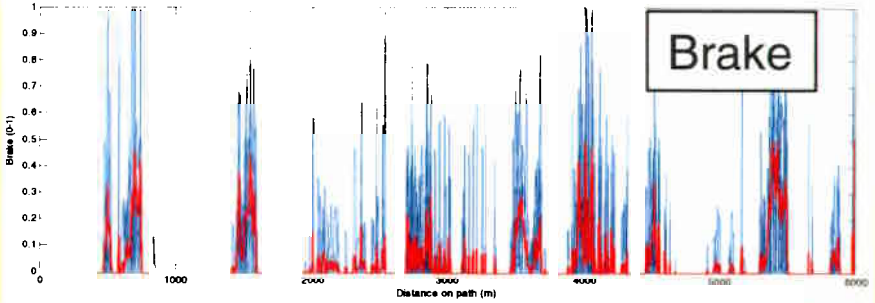
DCE1.1 Results: Path Averaging

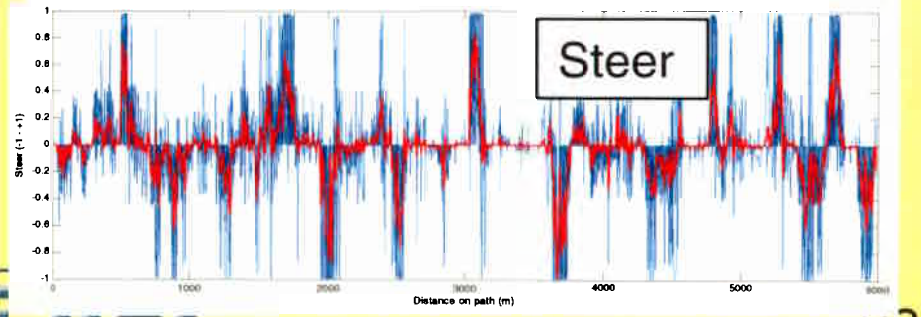
- Find average path
- Synchronize data at each point.
- 2m averaging











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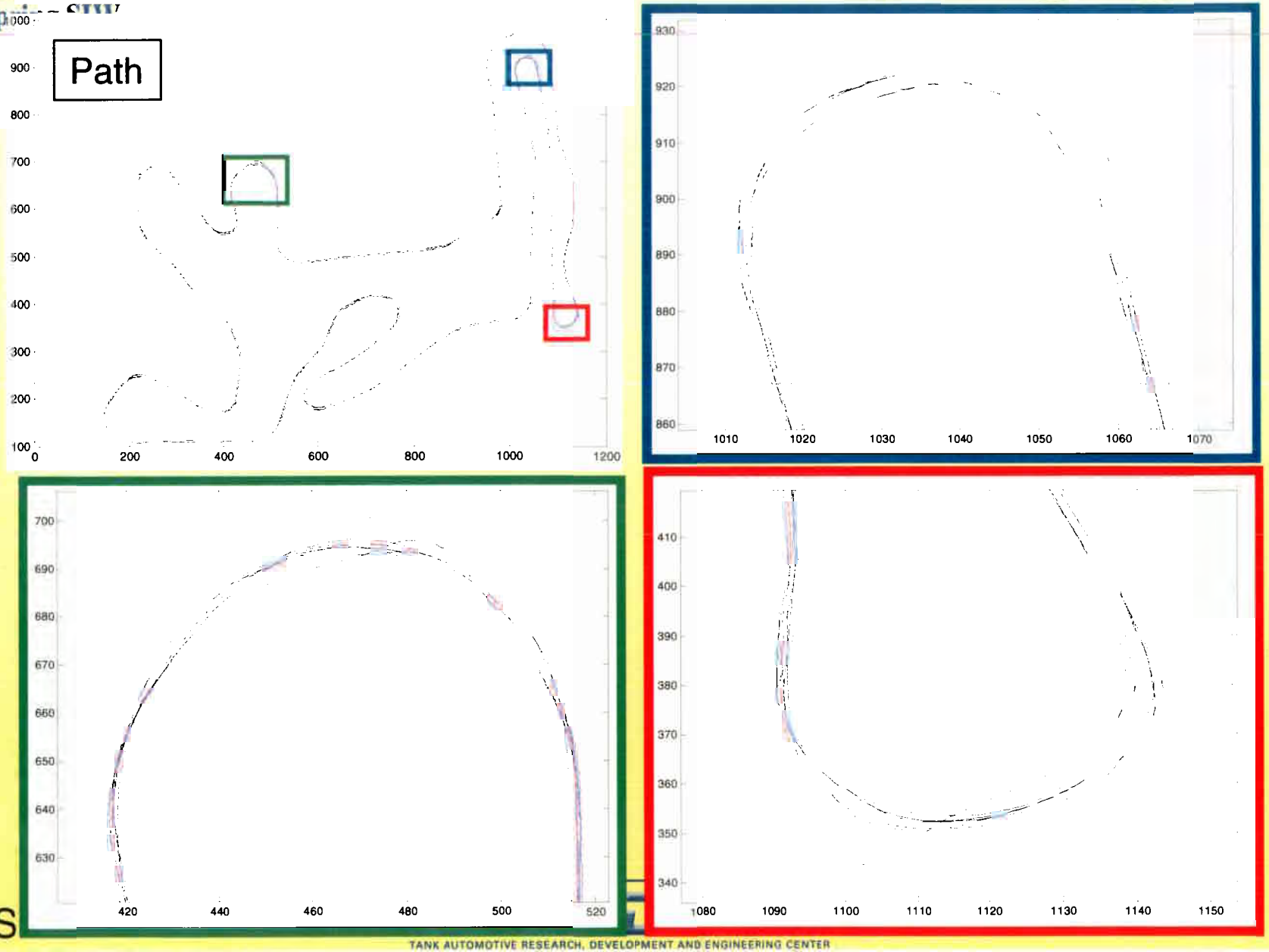

Conclusions

- Two duty cycles were recorded.
  - Battle scenario with driving and defensive systems.
  - Power train evaluation course.
- Motion base simulation affects how a vehicle is operated.
- A scenario may be extracted from a force-on-force simulation and executed at a higher resolution.